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Noise dosimetry survey of Land Force occupations

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Defence R&D Canada
Technical Report
DRDC Toronto TR 2008-062
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Abstract

This noise survey assessed the noise exposure sustained by combat arms personnel during a military exercise at Canadian Forces Base (CFB) Petawawa in 2006. Participants were asked to wear personal noise dosimeters during various basic operations (Raid, Convoy and Infantry Rehearsal Operations). Exposure beyond the allowed limit was documented in some operations (Raid and Convoy). Despite exposures beyond suggested limits, no hearing protection was worn or made available to the soldiers during the entire duration of the military operation.

Résumé

Le présent relevé de bruit a permis d'évaluer l'exposition reçue par des personnes œuvrant dans les armes combats lors d'un exercice de la réserve militaire à la base de Petawawa. On a demandé aux participants de porter des sonomètres intégrateurs personnels pendant différentes mission de niveau élémentaire. Des surexpositions au bruit ont été noté dans certaines opérations, comme le dans l'assaut et l'extraction en hélicoptère. Aucun soldat ne s'est équipé de protection auditive ou n'a eu accès à des protections auditives tout au long de l'exercice.

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Executive summary

Noise dosimetry survey of Land Force occupations

Eric Drolet, Sharon M. Abel ; DRDC TR 2008-062; Defence R&D Canada – Toronto.

Introduction: The effect of high-intensity noise on military personnel, in combat or training, is well understood. The association between noise exposure and hearing loss has been documented through the claims made by the military and ex-military personnel to Veterans Affairs Canada (VAC). The continuing escalation in the number of claims received by VAC is a clear indication that there are serious obstacles to implementing a successful hearing conservation program. One of the major concerns from military personnel is that hearing protection might interfere with situational awareness - the ability to detect, discriminate and localize hazard and communicate with team members.

The aim of this study was to assess the noise exposure associated with different tasks performed during training by reserve combat arms personnel. Participants were asked to wear personal noise dosimeters during various basic operations (Raid, Convoy and Infantry Rehearsal Operations).

Results: In some specific cases during this military exercise, noise exposures were above the Canada Labour Code guideline (Raid Task, Driving Task) of 87 dBA for 8 hours.

Significance: Soldiers were not briefed about the level of noise exposure they would experience and the possible risk to their hearing. Clearly, information regarding noise exposure and noise induced hearing loss (NIHL) are lacking in military operational settings.

Future plans: A longitudinal study on hearing loss for soldiers deployed on combat operations should be undertaken. Safety and education seminars are needed at the different leadership levels on hearing loss and prevention. These seminars should also include practical components on topics such as ear plug selection and insertion.

Sommaire

Relevé d'Exposition au Bruit d'Occupations de l'Armée de Terre

Eric Drolet; Sharon Abel; DRDC TR 2008-062; R & D pour la défense Canada – Toronto.

Introduction : Les effets du bruit de hautes intensités sur le personnel militaires sont identifiés depuis de nombreuses années. Cependant les réclamations des anciens combattants pour pertes auditives ne cessent d'augmenter. Il devient clair que les programmes de prévention ou les outils de protection (bouchons d'oreilles, protège-tympons ou serre-tête antibruit) ne sont pas adaptés à la réalité militaire. Il est certain que les militaires ont des besoins et des limitations très spécifiques. Les militaires sont toujours la crainte de perdre de l'information sur leur environnement lorsqu'ils portent des protections auditives. Cette étude a pour but d'évaluer les niveaux de bruit auquel les militaires sont exposés et constater l'utilisation de protection auditive dans ces conditions. Les soldats ont porté des sonomètres intégrateurs personnels pendant différentes missions de niveau élémentaire (assaut, extraction en hélicoptère, Activité de Transport).

Résultats : Des surexpositions au bruit ont été notées dans certaines opérations, comme le dans l'assaut et l'extraction en hélicoptère. Aucun soldat ne s'est équipé de protection auditive ou n'a eu accès à des protections auditives tout au long de l'exercice.

Importance : Cette étude démontre que les soldats en exercice ne sont pas protégés suffisamment pour l'exposition au bruit. Des lacunes concernant leur éducation sur le port de protection auditive ainsi que le risque de perte auditive lors d'exposition prolongée au bruit ont été constatées.

Perspectives : Une étude longitudinale sur la perte auditive sur les soldats déployés serait un autre outil pour développer une stratégie efficace afin de protéger les soldats. Un cours sur les risques de l'exposition aux bruits ainsi que le port de protection auditive serait un autre outil important dans la lutte contre la perte auditive.

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1 Introduction

The effects of high-intensity noise on military personnel, in combat or training, have been described since the 16th century (1). Five centuries later, the problem associated with noise-induced hearing loss and ear injury continues to be inextricably linked to military service, particularly in times of war (2). Technological changes in combat technology (e.g., jet propelled aircraft) introduced during World War II and the Korean War (1950-1953) resulted in a significant number of veterans with service-related noise-induced hearing loss (NIHL) (3).

This problem was the impetus for the US Air Force to publish the first US noise exposure regulation entitled “Precautionary Measures against Noise Hazard” in 1949. The high-noise exposure problem was such a growing concern in the US that a Committee on Hearing and Bioacoustics (CHABA) was created in 1953 (3). The committee concluded that high intensity noise exposure causes:

- aural pain
- hearing loss
- communication problems
- difficulty with orientation in space
- central nervous system effects
- psychological effects

Because of the wide range of effects, high intensity noise exposure was also a concern for the Canadian Armed Forces. Six years after the publication of the CHABA report, the first Canadian hearing conservation program was introduced. In 1959, Neely (4) outlined the first Canadian military hearing protection program: “Hearing Conservation for Armed Forces”. The components included noise measurement, the reduction of noise at the source where possible, education on the hazards of noise exposure, utilization of personal hearing protection and the regular monitoring of hearing.

In spite of the fact that a hearing conservation program has been in effect for 50 years the prevalence of noise-induced hearing loss among military personnel has been escalating. In fact, noise is the most common occupational health hazard in the Canadian Forces (CF) working environment (5,6). The association between noise exposure and hearing loss has been documented through the claims made by the military and ex-military personnel to Veterans Affairs Canada (VAC). According to VAC (see Table 1), the cost of audiological services (including hearing aids) amounted to \$41 million for 49,580 people in 2006 (7). If the number of claims is compared with the actual Canadian Forces population (roughly 60,000 regular forces members), it can be concluded that NIHL is a serious concern that must be addressed as this is a preventable disability.

	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
Clients receiving POC 03 benefits	36,427	37,201	38,321	40,836	43,849	45,901	49,580
POC 03 Expenditures	\$20,643,264	\$22,640,849	\$28,561,306	\$35,443,566	\$37,291,720	\$37,638,920	\$41,418,791
Average Expenditure per Client	\$566.70	\$608.61	\$745.32	\$867.95	\$850.46	\$820.00	\$835.39
		\$41.91	\$136.71	\$122.63	-\$17.49	-\$30.46	\$15.39
Annual % change		7.39%	22.46%	16.45%	-2.02%	-3.58%	1.88%

Table 1 Claims From Veterans Affairs from 1999 to 2006

The number of claims received by VAC is a clear indication that there are serious obstacles to implementing a successful hearing conservation (8). Military personnel are concerned that hearing protection might interfere with situational awareness - the ability to detect, discriminate and localize hazard and communicate with team members. There is also the issue of compatibility with other devices and gear, like helmets and communication equipment.

In order to assess the degree of noise exposure among military personnel, a noise dosimetry survey was undertaken during a major training exercise. The military training platform is a challenging environment with respect to hearing conservation because noise exposure tends to be highly variable (noise levels associated with heavy tanks, artillery guns, rifles and construction equipment range from 80 to 150 dBA) and the transition from a quiet to loud surroundings is often rapid (6).

2 Aim

The aim of this study was to assess the noise exposure associated with different tasks performed during training by reserve combat arms personnel. Three tasks were surveyed during this trial:

- Raid Tasks; deliberate attack on a target
- Mounted Patrol Tasks, i.e., patrol with military vehicle on road
- Raid Rehearsal practice in camp; exercise where military personnel practice basic skills required to perform the raid (i.e., entrance in building, evacuation of prisoners and wounded, etc.)

The approach used in this study was to assess personal noise dosimetry over a period of several hours during a training exercise. The duration of each noise measurement was mission specific, i.e., the recording started with the beginning of the task and ended with the termination of the task.

The exposure data were compared with the Canada Labour Code guideline for noise exposure. Field observations were made by the survey team on the use of hearing protection and the subjects were asked questions with respect to their perceived exposure and their knowledge of the hearing conservation program in the CF.

3 Methods

In order to document operational noise exposure in a tactical environment the data were collected in a large-scale military exercise. The exercise selected for this study was the Vigilant Guardian 2006 (VG06). During this exercise, more than two thousand military reservists from across Ontario gathered at Canadian Forces Base Petawawa.

3.1 Military Exercise

VG06 was a nine-day exercise designed to practice a wide spectrum of skills required on Canadian military operations. For example, soldiers practiced tasks that are now performed in Afghanistan (i.e., airborne raid on designated target, see Figure 1). VG06 included all of the 40 Reserve units from the Land Force Central Area. In the training scenario, task forces were grouped under a Multi-National Brigade Headquarters, which included several groups of infantry, an artillery battery, an engineering squadron and an armoured reconnaissance squadron. Table 2 outlines the main characteristics of VG06.



Figure 1 Soldier During VG06

Picture From Maple Leaf Journal (http://www.mdn.ca/site/Community/mapleleaf/index_e.asp)

VIGILANT GUARDIAN FACTS

Start	Saturday 19 August 2006
Finish.....	Sunday 27 August 2006
Location.....	CFB Petawawa (Matawa Plain)
Troops expected.....	2000 plus
Budget.....	\$4 million
Scenario.....	Failed state
Main activities.....	Force Protection, Stability Ops, Direct Action
Who.....	31, 32, 33 Canadian Brigade Groups
Support.....	Health Services; Communication; Military Police; 400 and 427 Tactical Helicopter Squadrons; 2 Canadian Mechanized Brigade Group

Table 2 Vigilant Guardian 2006 Information

3.2 Exposure Conditions

VG06 was designed to replicate a real operational environment experienced by the troops while deployed in Afghanistan. In this framework, several kinds of exposure conditions were surveyed.

- Typical infantry task: a raid

A raid is a violent attack on a specific objective (i.e., house) in order to capture or destroy a specific element. A raid consists of three phases: the platoon moves to the specific objective, attacks the objective and returns to the base. The noise dosimeter was operational during each phase of the raid without interference of the experimental team. During a raid various types of noise are encountered (impact noise from small arms, helicopter noise and low-intensity blasts).

- Typical armoured task: a mounted patrol.

During a patrol, a series of vehicles form a convoy and move from point A to point B. During their move, they ensure security and report any suspicious actions. Different noise profiles are encountered: engine noise, heavy machinery, impact noise from small arms.

- Raid Rehearsal practice in camp

All military activity that required a rapid execution and precision, like the raid, were rehearsed a couple of hours prior to the departure for the mission. The platoon practiced the assault actions

that would be performed for the objective. In this case, the platoon moved tactically from one side of the camp to the other side of the camp. They practiced different hand signals, and road crossing drills. They hid behind park vehicles, tents, and compressors. When the platoon reached the mock target (an improvise shelter), the platoon practiced the assault plan drafted by the platoon commander.

During each condition, the experimenters ensured that noise dosimeters were properly worn and gathered information without interfering with the normal military activity. The duration of each condition was mission specific; from 2 hours to 8 hours. The noise survey evaluation started with the departure of the troops and ended with either the return to the operation base or having the mission objective completed.

3.3 Procedures

Prior to each experimental condition, the calibration of each dosimeter was checked. A microphone windscreen was put over the microphone to protect the microphone or to ensure that wind did not affect the measurement. After each experimental condition, the noise dosimeter was connected to a computer in order to download the data file.

Up to twelve individuals participated in this survey during each day of this three day study. They met with the experimenter at least one hour before the start of the mission. Each participant filled out a Volunteer Consent Form. The participants were read the instructions created by the experimenter (Annex A, A.1). The experimenter helped the participants attach the dosimeter to their clothing. The dosimeter's microphone was attached close to the left ear by clipping it to the collar or epaulet (Figure 2). The wire from the microphone was fed under the participants clothing to prevent it from snagging and the dosimeter was clipped to the participant's belt or placed in a pocket. The participants were asked to return the dosimeter to the experimenter at the end of their mission. The experimenter answered any questions or concerns that the participants had. Upon returning the dosimeters, the participants were asked to complete an Activity Questionnaire (Appendix A, A.2) describing the tasks they performed and equipment used that day. Once all the dosimeters were collected, the experimenter downloaded the data onto the laptop and prepared the dosimeters for the next day of data collection.



Figure 2 Soldier Fitted With a Dosimeter Microphone

Picture From Massel and Kumagai, 2003

3.4 Equipment

The equipment used in this survey included twelve Q-300 dosimeters, a calibrator and QuestSuite software. A brief description of each is given below.

3.4.1 Dosimeters

Twelve Q-300 dosimeters (Quest Technologies, Oconomowoc, Wisconsin) were used (Figure 3). The Q-300 dosimeter is a data logging personal noise dosimeter and integrated sound level meter combined into one unit (see Table 3 for characteristics). The unit calculates, displays and stores sound pressure levels, maximum and minimum levels, peak levels, averages (L_{EQ} or L_{AVG}), time weighted averages, sound exposure levels, dose and projected dose, and exposure in Pascal squared hours (the sound pressure x the number of hours of exposure). Note that these are defined below in Section 3.5. Time histories for average levels, max and peak, plus statistical tables are readily available for printout. The Q-300 performs the calculations for three dosimeters operating simultaneously in one instrument (5).



Figure 3 Q-300 Noise Dosimeter

Picture From Massel and Kumagai, 2003

Measuring Range	40 to 110 dB, 70 to 140 dB (user selectable)
Frequency Weighting	A, C (user selectable)
Exchange Rate	3, 4, 5, 6 dB (user selectable)
Standards	ANSI S1.25, S1.4, IEC 651, 804, 1252
Power	9V battery, 48 hours operation
Dimensions	(HWD) 5.5" x 2.8" x 1.4"
Weight	15.5 oz

Table 3 Quest Q-300 Noise Dosimeter Characteristics

3.4.2 Calibrator

The QC-20 sound level calibrator (Quest Technologies, Oconomowoc, Wisconsin) provides a quick, precise field calibration of the dosimeter (Figure 4). The calibrator generates a stable acoustic signal at a controlled frequency and amplitude to verify the measurement accuracy of a sound level meter in the field. With the QC-20 sound level calibrator the user can select one of two levels (94 dB or 114 dB) and one of two frequencies (250 Hz or 1,000 Hz) to generate four different possible outputs. For this survey the calibrator was set at 114 dB and 1,000 Hz. It has a standard one-inch coupler opening that may be reduced by inserting available snap-in adapters.



Figure 4 QC-20 Calibrator

Picture From Massel and Kumagai, 2003

3.4.3 QuestSuite Software

QuestSuite software (Quest Technologies, Oconomowoc, Wisconsin) downloads data from the dosimeters and stores, archives, and organizes it in a data file on the computer. It provides search criteria to assess the data. It has graphic tools to help analyse the data in 2-dimensional, 3-dimensional, bar charts and line graphs (Figure 5). The dosimeter parameters were uploaded from the QuestSuite software. QuestSuite software ran on a Dell Latitude C600 laptop (Dell, Inc., Round Rock, Texas) during this survey (5).

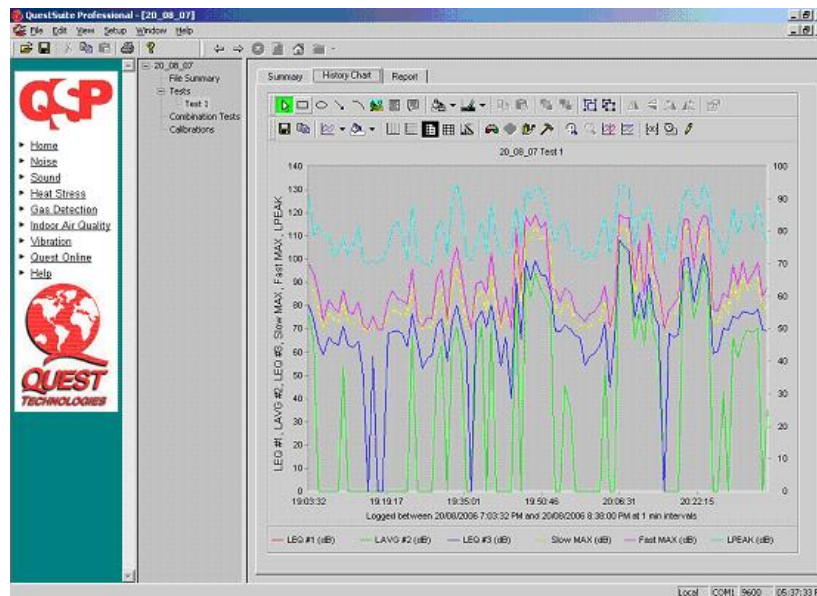


Figure 5 QuestSuite Software

3.5 Measures

Each dosimeter was configured with a logging interval of one minute, meter range of 70-140 dB, and a projected period of eight hours. The Q-300 performed calculations for three dosimeters

operating simultaneously in the one instrument. The parameters of the three dosimeters within each Q-300 instrument are presented in Table 3. The dosimeter parameters were determined by various legislative guidelines that were in effect at the time of the trial. The weighting and time constant value were the same for all three dosimeters (5).

Measures are defined as follows:

Weighting: Human hearing is not equally sensitive in all frequencies. Human hearing is not as sensitive at the low frequencies as at the high frequencies (9). Sound level meters typically provide different weightings (A,B,C and D) for measurement of sound level depending on the objective (see Figure 6). The most common filter used in dosimetry is the “A” filter, which models human sensitivity.

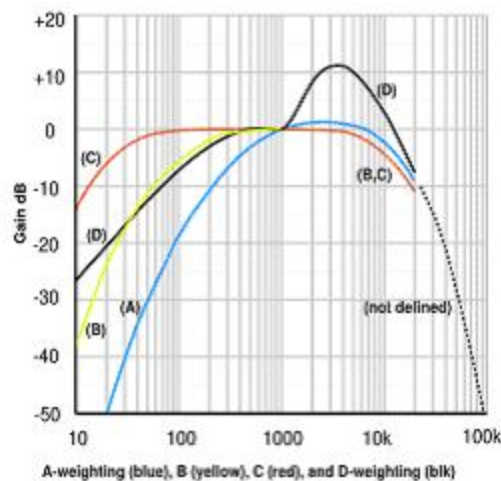


Figure 6 Weighting Curve

Picture From Wikipedia Website

Exchange Rate : Exchange rate refers to how the sound energy is averaged over time. According to the 3 dB exchange rate in most common usage, every time the sound energy doubles, the measured level increases by 3 dB. For every increase of 3 dB in the time-weighted average the measured noise dose would double. The US Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration use a 5 dB exchange rate. OSHA has argued that the human ear self-compensates for changing noise levels and thus the 3 dB exchange rate should be changed to more closely match the response of the human ear.

Criterion Level : The criterion level is used in the dose calculation. If the dosimeter is exposed to a decibel level equal to the criterion level for 8 hours the result will be 100% dose. The criterion level is typically set by a regulating agency such as OSHA and usually not applicable for community noise monitoring.

Time Constant : The response determines how quickly the unit responds to fluctuating noise. Fast refers to a time constant of 125 milliseconds. Slow refers to a time constant of 1 second.

Threshold : The threshold affects the L_{AVG} , TWA, and dose measurements (see below). All sound levels below the threshold are considered non-existing noise for the averaging and integrating functions. The threshold does not affect measurements in the sound level mode.

Average Sound Level (L_{AVG}): L_{AVG} is the average sound level measured over the run time. This becomes a bit confusing when thresholds are used. Any sound below the threshold is not included in this average. Sound is measured in a logarithmic scale. Therefore, the average cannot be computed by simply adding the levels and dividing by the number of samples. When averaging decibels, short durations of high levels can significantly contribute to the average level.

Time Weighted Average (TWA): The time-weighted average always averages the sampled sound over an 8-hour period. TWA starts at zero and then increases. The TWA is less than the L_{AVG} if the run time is less than eight hours, and increases more than L_{AVG} after eight hours.

For this study both average Sound Level (L_{AVG}) and Time Weighted Average (TWA) were calculated.

The Dosimeter Settings (see Table 4 for overview)

Dosimeter Setting #1

This setting represents guidelines provided by the Canadian Labour Code (<http://laws.justice.gc.ca>). The threshold value was set at 70 dBA. According to the Canada Occupational Health and Safety Regulations (SOR/86-304) Chapter 7.2 Para 3:

For the purposes of this Part, the measurement and calculation of the noise exposure level ($L_{ex, 8}$) to which an employee is exposed shall take into account the exposure of the employee to A-weighted sound pressure levels of 74 dBA and greater.

The exchange rate (3 dB) and criterion level are also given by the code. The upper limit value was set at 87 dBA. This upper limit gives the time (in minutes) where the limit, of 87 dBA, was exceeded.

Dosimeter Setting # 2

Settings for Dosimeter #2 represent the legislation in at the time this study was conducted under the Ontario Health and Safety Act (OHSA). During the writing of this document, the legislative framework for noise exposure changed. Dosimeter Setting #3 represents the new standard. The threshold value was not defined under the previous Act, therefore the threshold value for this setting was in accordance with CSA Standard Z107.56-06 (<http://www.csa-intl.org>), i.e., 80 dBA. The exchange rate (5 dB) and criterion level (90 dBA) are also given by the Act. The upper limit value was set at 90 dBA. This upper limit value gives the time (in minutes) where the limit, of 90 dBA, was exceeded.

Dosimeter Setting # 3

This setting represents the legislation in effect under the current Ontario Health and Safety Act (OSHA). The threshold value is not defined under the Act, therefore the threshold value for this setting is in accordance with CSA Standard Z107.56-06 (<http://www.csa-intl.org>), i.e., 80 dBA. The exchange rate (3 dB) and criterion level (85 dBA) are given by the code. The upper limit value was set at 140 dBA. This upper limit gives the time (in minutes) where the limit, of 140 dBA, was exceeded.

	Setting 1	Setting 2	Setting 3
Weighting	A	A	A
Threshold	70dB	80dB	80dB
Exchange Rate	3dB	5dB	3dB
Criterion	87dB	90dB	85dB
Time Constant	Slow	Slow	Slow
Upper Limit	87dB	120dB	140dB

Table 4 Dosimeters Parameters

3.6 Limitations

For occupations where individuals were required to wear headphones to receive communications, the dosimeter readings may not accurately reflect noise exposure to the ears. There are two issues. First, the headphones may attenuate ambient noise. Secondly, the communications presented over the headphones may add to the ambient, effectively increasing to the level of the exposure.

3.7 Mathematical Procedures

Average of noise level were performed using the following formula:

$$L_t = 10 \log \left(\sum_i 10^{L_i/10} \right)$$

Where L_t is total sound pressure level, L_i is the individual sound pressure level.

4 Results

The noise survey was carried out for the following:

- Raid tasks
- Mounted patrol task
- Raid rehearsal around camp task

4.1 Raid Tasks

One of the main basic and critical tasks of any infantry unit is to be able to perform a raid on a target (i.e., house, vehicle, etc.). In order to carry out the raid, a group of 30 men (infantry platoon) was divided into two distinct groups: an assault group (18 men) and a support group (12 men). In military terms, these are referred to as an assault group and a fire base group. The assault group performed the actual attack on the target. The support group provided protection to the assault group by shooting at the target until the assault group could safely take the target. Figure 7 illustrates a schematic raid plan.



Figure 7 Raid Schematic Diagram

The levels of noise exposure associated with the performance of these two distinctive tasks (assault and support group) was different. Thus, for this study, the two groups were monitored separately. Once the assault was completed the whole group (platoon) was evacuated by helicopter to the main camp.

4.1.1 Overall Noise Exposure

Prior to the raid task, twelve soldiers were equipped with noise dosimeters; six dosimeters were distributed randomly to the assault group and six noise dosimeters were distributed randomly to the support group. Noise exposure was then averaged for the whole group and was also broken

down for the assault and support groups separately. Figure 8 shows the noise exposure profile. The data were taken from Dosimeter Setting 1 (threshold 70 dB). The noise profile was divided into five different regions (see Figure 8) as follows:

- **Tactical movement region:** the platoon is moving quietly toward the target
- **Attack peak region :** assault is taking place,
- **Actions on target:** all the action required on the target (e.g., recover hostages, destroy enemy property, etc.)
- **Helicopter extractions peak region:** the Griffon helicopters are transporting the entire platoon
- **End of Raid Task:** all the procedure that are needed when soldiers return from a task (e.g., count all ammunition expended, check military kit to see if something is missing, debrief from leader, after action report, etc.)

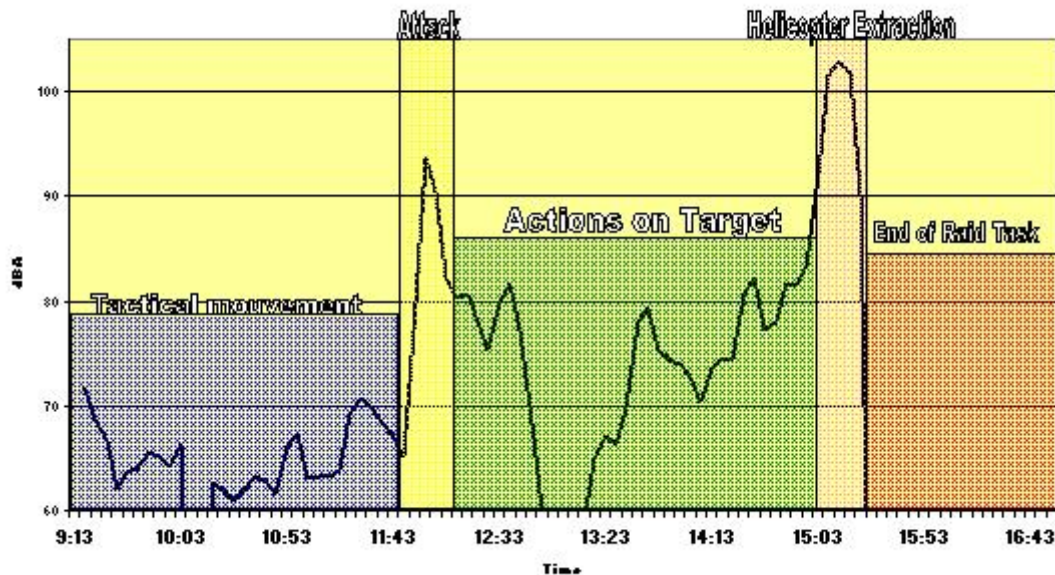


Figure 8 Noise Exposure Profile of the Raid Task

The noise exposure data are summarized in Table 5. The noise exposure averages (L_{AVG}) from Dosimeter Settings #1 and #3 are equivalent because they share the same weighting and threshold values. Dosimeter Setting #2 had a different threshold level. The assault and support group noise exposure values are given for the whole raid, as well as separately for the assault exposure (15 minutes) and helicopter extraction (1 hour).

Platoon Exposure	Settings 1 and 3 N=12	Setting 2 N=12	Time
Average Total Exercise (TWA)	90.3 dBA	91.6 dBA	8 hours
Average Assault (L_{AVG})	98.6 dBA	96.8 dBA	15 min
Average Helicopter Extraction (L_{AVG})	97.3 dBA	97.5 dBA	1 hour
Assault Group	Settings 1 and 3 N=6	Setting 2 n=6	Time
Average Total Exercise (TWA)	89.8 dBA	93.0 dBA	8 hours
Average Assault (L_{AVG})	90.4 dBA	86.7 dBA	15 min
Average Helicopter Extraction (L_{AVG})	97.7 dBA	98.5 dBA	1 hour
Support Group	Settings 1 and 3 n=6	Setting 2 n=6	Time
Average Total Exercise (TWA)	90.7 dBA	89.6 dBA	8 hours
Average Assault (L_{AVG})	101.3 dBA	99.6 dBA	15 min
Average Helicopter Extraction (L_{AVG})	97.0 dBA	96.0 dBA	1 hour

Table 5 Average Exposure and Time Weighted Average for the Raid Task

4.1.2 Noise Distribution of the Attack Portion

Noise exposure data of the Raid Task were collected for two groups; the assault group and the support group. The histogram of Figures 9 and 10 below illustrate the noise distribution in minutes from each noise dosimeter setting. These graphs represent a one-minute average from the noise dosimeter of the attack group and the support group (N=6 for each group). There are no data below the threshold value from each dosimeter setting, in this case 70 dBA for Dosimeter Setting #1 and Noise Dosimeter Setting #3, and 80 dBA for Noise Dosimeter Setting #2.

Table 6 shows the noise exposure distribution from the two groups. There are no data below the threshold value from the noise dosimeter. Every minute represents an integrated average.

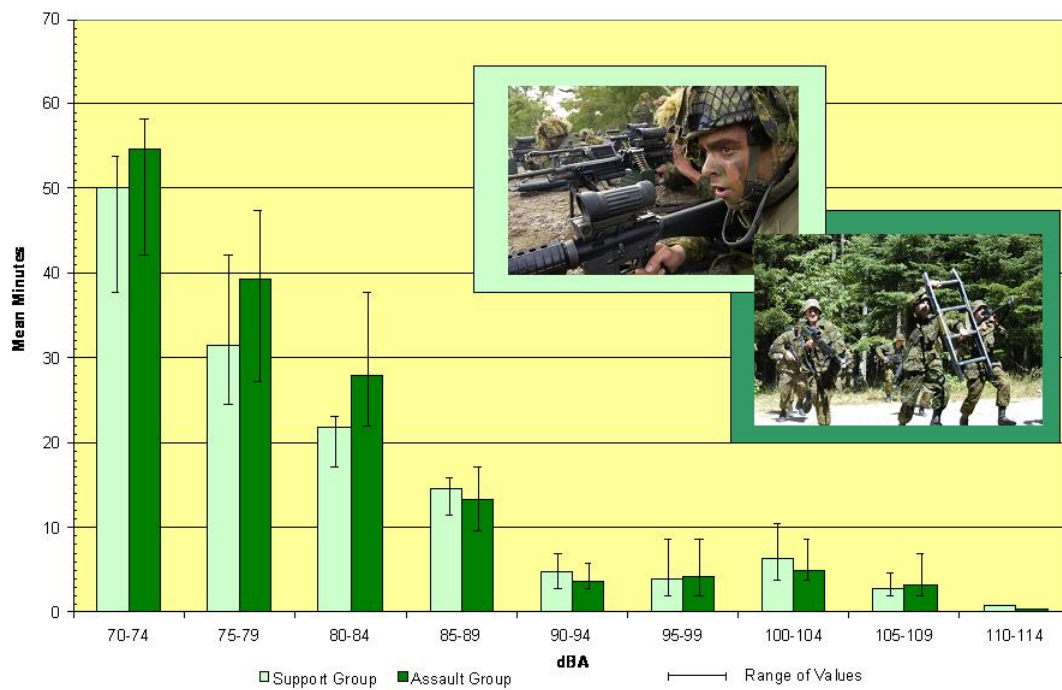


Figure 9 Noise Exposure Distributions for the Assault and Support Groups with Dosimeter Settings 1 and 3

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

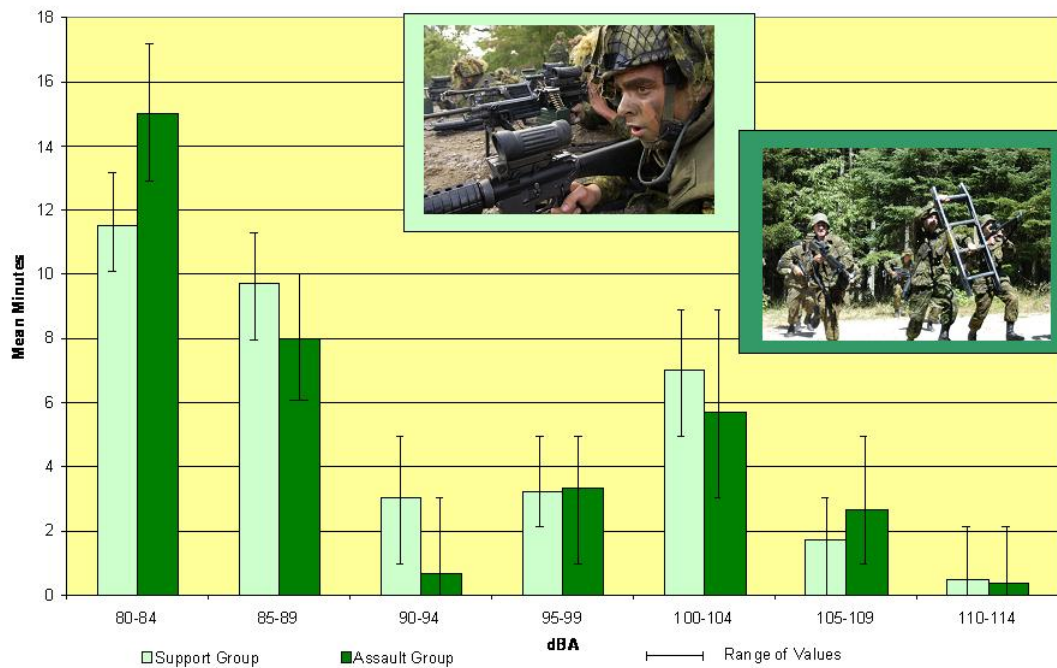


Figure 10 Noise Exposure Distributions for the Assault and Support Groups with Dosimeter Setting 2

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

dBA	Settings 1 and 3	
	Assault Group Average Time (Minute) N=6	Support Group Average Time (Minute) N=6
70-74	54.7	50.0
75-79	39.3	31.5
80-84	27.7	21.8
85-89	13.0	14.5
90-94	3.7	4.8
95-99	4.3	4.0
100-104	3.7	6.3
105-109	3.3	2.8
110-114	0.3	0.8
Setting 2		
80-84	15.0	11.5
85-89	8.0	9.8
90-94	0.7	3.0
95-99	3.3	3.2
100-104	5.7	7.0
105-109	2.7	1.8
110-114	0.3	0.5

Table 6 Noise Exposure Distributions for the Support and Assault Groups

4.2 Mounted Patrol Tasks

Dosimetry measurements were made for individuals who worked in the following vehicles:

- G-Wagon (combat and administrative purpose 4x4 vehicle made by Mercedes)
- Iltis (combat and administrative purpose 4x4 currently being replace by the G-wagon)
- Light Support Vehicle (Administrative Vehicle used to supply troops)
- Heavy Logistic Vehicle (Administrative Vehicle used to transport and pull heavy charge like trailers loaded with heavy machinery)
- Medium Logistic Vehicle (Administrative Vehicle used to transport troops and medium size equipment)
- Light Utility Vehicle (Military version of Civilian Pick-up truck)

4.2.1 G-Wagon Exposure

Four soldiers were selected to wear dosimeters during the G-Wagon condition. During the exposure, the G-wagon patrolled the road in the training area of CFB Petawawa for 273 minutes.

The patrol mainly escorts other logistics vehicles, controls the traffic on the road and reports and investigates any suspect activities. During this exposure, no small arms were used and the patrol did not use any hearing protection. According to the survey at the end of the patrol, the patrol was similar to a “real” life scenario.

The average exposure (L_{AVG}) for the four soldiers inside the G-Wagon was calculated with the three noise dosimeter settings (Settings 1, 2 and 3). Noise exposure average per minute was calculated (see Table 7) and plotted on the graph below (Figure 11). An average noise exposure for 8 hours (TWA) was extrapolated for the data collected (Table 8) using the three different dosimeter settings. There were no data below the threshold value from each dosimeter setting, i.e., 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

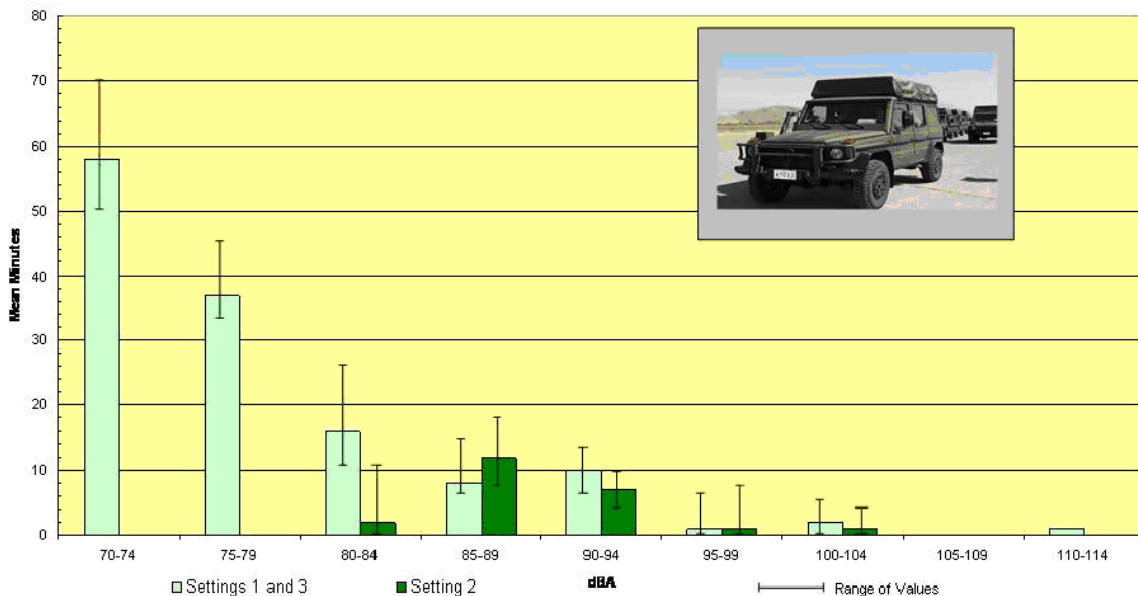


Figure 11 G-Wagon Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=3	Setting 2 N=3
dBA	Minutes	Minutes
70-74	58	NA
75-79	37	NA
80-84	16	2
85-89	8	12
90-94	10	7
95-99	1	1
100-104	2	1
105-109	0	0
110-114	1	0

Table 7 Noise Exposure Distribution for the G-Wagon

	Dosimeter Setting N=3	
	Settings 1 and 3	Setting 2
Average total exercise exposure (273 minutes) (L_{AVG})	87.8 dBA	74.3 dBA
Projected 8 hours time weighted average (TWA)	85.4 dBA	70.3 dBA

Table 8 Average Exposure and Time Weighted Average for the G-Wagon

4.2.2 Iltis Exposure

Four soldiers wore dosimeters during the Iltis condition. The Iltis is being replaced by the G-Wagon. They both share the same role and duty. During this training scenario, the Iltis patrolled the road in the training area of CFB Petawawa for 274 minutes. During this exposure, no small arms were used and soldiers did not wear any hearing protection. According to the survey at the end of the exposure, the patrol was similar to a “real” life scenario.

An average exposure (L_{AVG}) with the four soldiers inside the Iltis was calculated with the three noise dosimeter settings (Settings 1, 2 and 3). Noise exposure average per minute was calculated (see Table 9) and plotted on the graph below (Figure 12). An average noise exposure for 8 hours (TWA) was extrapolated from the data collected (Table 10) using the three different settings (Settings 1, 2 and 3). There were no data below the threshold value from each dosimeter setting, i.e., 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

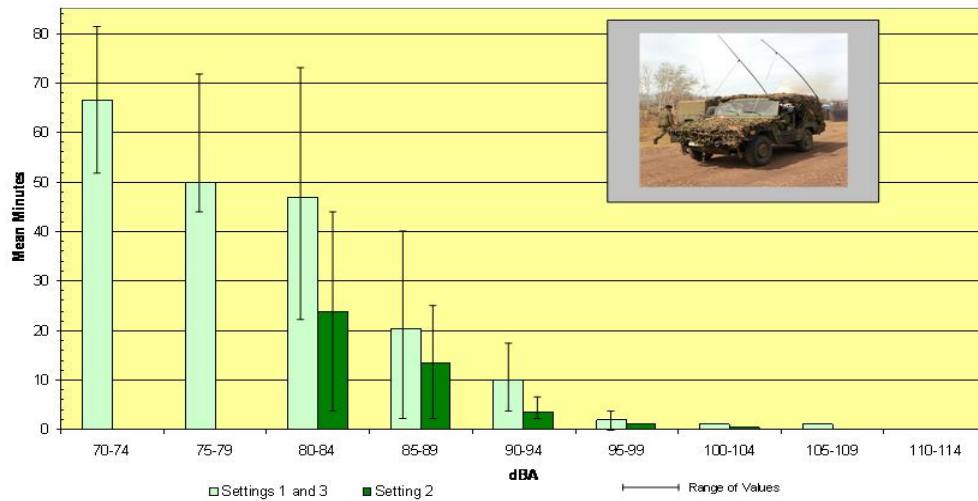


Figure 12 Iltis Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=4	Setting 2 N=4
dBA	Minutes	Minutes
70-74	66.5	NA
75-79	50	NA
80-84	47	24
85-89	20.5	13.5
90-94	10	1
95-99	2	0.5
100-104	1	1
105-109	1	0
110-114	0	0

Table 9 Noise Exposure Distribution for the Iltis

	Dosimeter Setting N=4	
	Settings 1 and 3	Setting 2
Average Total Exercise (L_{AVG})	83.6 dBA	74.7 dBA
Projected 8 hours time weighted average (TWA)	81.2 dBA	70.7 dBA

Table 10 Average Exposure and Time Weighted Average for the Iltis

4.2.3 Light Support Vehicle Wheeled (LSVW)

Four soldiers wore dosimeters for the Light Support Vehicle Wheeled condition. The LSVW transported various equipment and supplies between the camp and the main base. The drivers were required to load and unload the cargo area of the LSVW without the help of mechanized equipment. The transport task lasted 340 minutes. During this exposure, no small arms were used and soldiers did not wear any hearing protection. According to the survey at the end of the exposure, the patrol was similar to a “real” life scenario.

The average exposure (L_{AVG}) for the four soldiers inside the LSVW was calculated with the three noise dosimeter settings (Settings 1, 2 and 3). Noise exposure average per minute was calculated (see Table 11) and plotted on the graph below (see Figure 13). An average noise exposure for 8 hours (TWA) was extrapolated for the data collected (see Table 12) using the three different settings (Settings 1, 2 and 3). There were no data below the threshold value from each dosimeter setting, i.e., 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

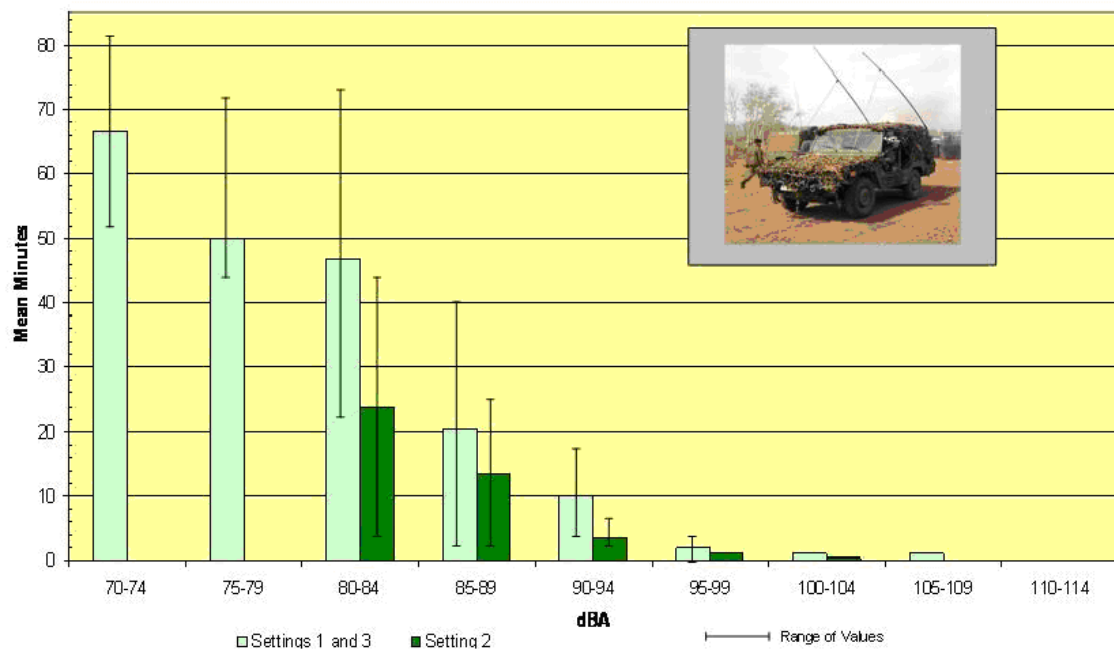


Figure 13 LSVW Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=3	Setting 2 n=3
dBA	Minutes	Minutes
70-74	77.0	NA
75-79	57.0	NA
80-84	36.0	14
85-89	6.0	12.5
90-94	9.5	4.5
95-99	9.0	2.5
100-104	3.5	1.5
105-109	0.5	0
110-114	0	0

Table 11 Noise Exposure Distribution for the LSVW

	Dosimeter Setting N=3	
	Settings 1 and 3	Setting 2
Average Total Exercise	104.4 dBA	94.7 dBA
Projected 8 hours time weighted average	103.1 dBA	92.5 dBA

Table 12 Average Exposure and Time Weighted Average for the LSVW

4.2.4 Heavy Logistics Vehicle Wheeled (HLVW)

Four soldiers wore dosimeters during the Heavy Logistic Vehicle Wheeled condition. During this exposure, the HLVW transported various heavy equipment (e.g., diesel gas generator) and supplies (e.g., boxes of food for the kitchen) between the camp and the main base. The drivers were required to load and unload the cargo area of the HLVW with the help of mechanized equipment, i.e., fork lift. The transport task lasted 351 minutes. During this exposure, no small arms were used and they did not use any hearing protection. According to the survey at the end of the exposure, the patrol was similar to a “real” life scenario.

An average exposure with the four soldiers inside the HLVW was calculated for each of the three noise dosimeters settings (Settings 1, 2 and 3). Settings 1 and 3 have the same and Setting 2 has a different threshold level. Noise exposure average per minute was calculated (see Table 13) and plotted on the graph below (see Figure 14). An average noise exposure for 8 hours (TWA) was extrapolated for the data collected (see Table 14) using the three different settings (Settings 1, 2 and 3). There are no data below the threshold value from each dosimeter setting, in this case 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

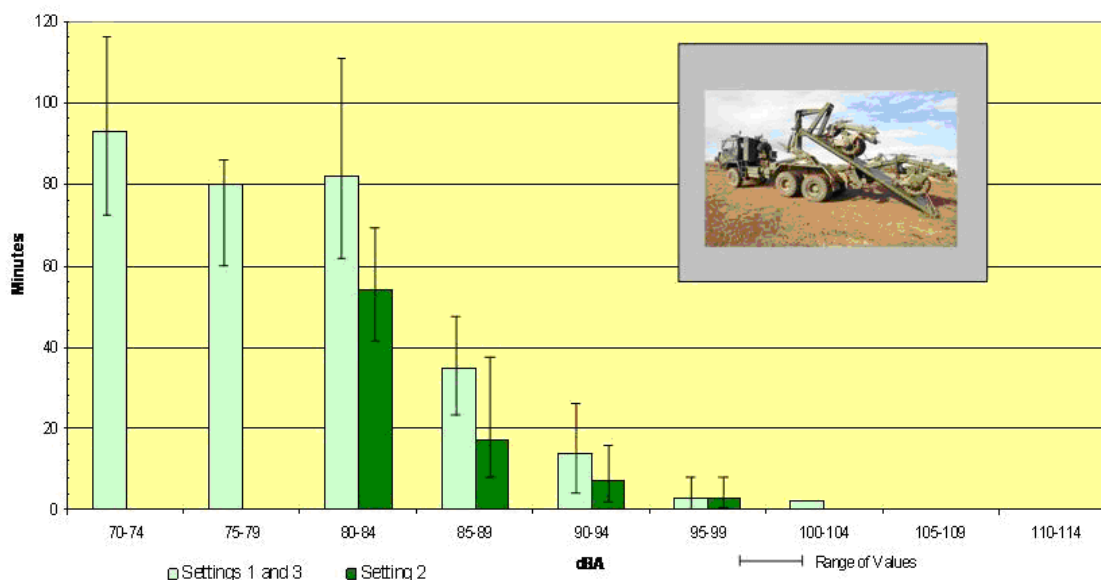


Figure 14 HLVW Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=3	Setting 2 n=3
dBA	Minutes	Minutes
70-74	93.0	NA
75-79	80.0	NA
80-84	82.0	54.0
85-89	35.0	17.0
90-94	14.0	7.0
95-99	3.0	3.0
100-104	2.0	0.0
105-109	0.0	0.0
110-114	0.0	0.0

Table 13 Noise Exposure Distribution for the HLVW

	Dosimeter Setting N=2	
	Settings 1 and 3	Setting 2
Average Total Exercise	82.8 dBA	75.4 dBA
Projected 8 hours time weighted average	81.4 dBA	75.1 dBA

Table 14 Average Exposure and Time Weighted Average for the HLVW

4.2.5 Medium Logistics Vehicle Wheeled (MLVW)

Four soldiers were selected to be surveyed during the Medium Logistics Vehicle Wheeled condition. During this exposure, the MLVW transported various equipment (e.g., back packs, tents, etc.) and troops, and pulled a portable water tank between the camp and the main base. The drivers were required to load and unload the cargo area of the MLVW with the help of mechanized equipment, i.e., fork lift. The transport task lasted 351 minutes. During this exposure, no small arms were used and the patrol did not use any hearing protection. According to the survey at the end of the exposure, the patrol was similar to a “real” life scenario.

An average exposure with the four soldiers inside the MLVW was calculated with the three noise dosimeter settings (Settings 1, 2 and 3). Settings 1 and 3 have the same and Setting 2 has a different threshold level. Noise exposure average per minute was calculated (see Table 15) and plotted on the graph below (see Figure 15). An average noise exposure for 8 hours (TWA) was extrapolated for the data collected (see Table 16) using the three different settings (Settings 1, 2 and 3). There are no data below the threshold value from each dosimeter setting, i.e., 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

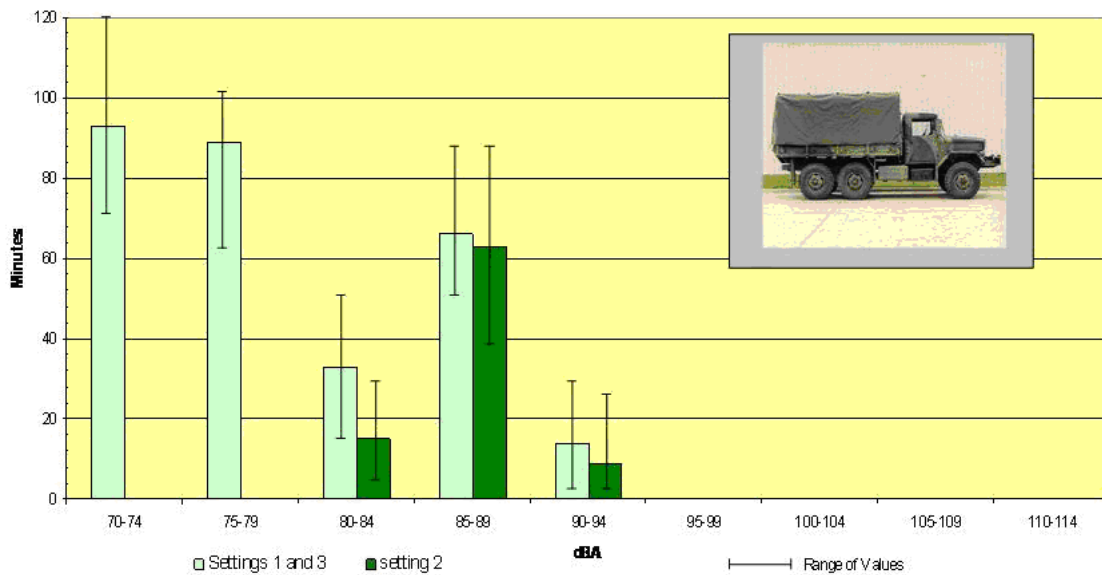


Figure 15 MLVW Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=3	Setting 2 N=3
dBA	Minutes	Minutes
70-74	93.0	NA
75-79	89.0	NA
80-84	33.0	15.0
85-89	66.0	63.0
90-94	14.0	9.0
95-99	0.0	0.0
100-104	0.0	0.0
105-109	0.0	0.0
110-114	0.0	0.0

Table 15 Noise Exposure Distribution for the HLVW

	Dosimeter Setting N=3	
	Settings 1 and 3	Setting 2
Average Total Exercise (L_{AVG})	83.3 dBA	78.6 dBA
Projected 8 hours time weighted average (TWA)	82.2 dBA	76.8 dBA

Table 16 Average Exposure and Time Weighted Average for the MLVW

4.2.6 Light Utility Vehicle Wheeled (LUVW)

Four soldiers wore noise dosimeters during the Light Utility Vehicle Wheeled condition. During this exposure, the LUVW transported various small pieces of equipment and personnel between the camp and the main base. The transport task lasted 281 minutes. During this exposure, no small arms were used and the patrol did not use any hearing protection. According to the survey at the end of the exposure, the patrol was similar to a “real” life scenario.

An average exposure with the four soldiers inside the LUVW was calculated with the three noise dosimeter settings (Settings 1, 2 and 3). Settings 1 and 3 have the same and Setting 2 has a different threshold level. Noise exposure average per minute was calculated (see Table 17) and plotted on the graph below (see Figure 16). An average noise exposure for 8 hours (TWA) was extrapolated for the data collected (see Table 18) using the three different settings (Settings 1, 2 and 3). There were no data below the threshold value from each dosimeter setting, i.e., 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

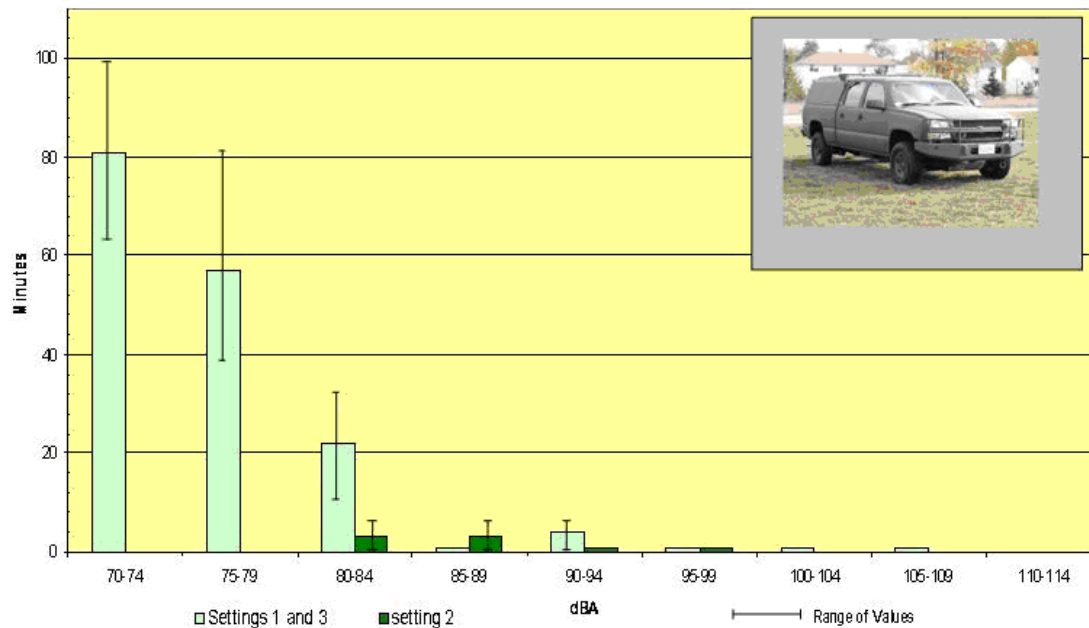


Figure 16 LUVW Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=3	Setting 2 n=3
dBA	Minutes	Minutes
70-74	81.0	NA
75-79	57.0	NA
80-84	22.0	3.0
85-89	1.0	3.0
90-94	4.0	1.0
95-99	1.0	1.0
100-104	1.0	0.0
105-109	1.0	0.0
110-114	0.0	0.0

Table 17 Noise Exposure Distribution for the LUVW

	Dosimeter Setting N=3	
	Settings 1 and 3	Setting 2
Average Total Exercise	90.7 dBA	79.4 dBA
Projected 8 hours time weighted average	88.4 dBA	75.6 dBA

Table 18 Average Exposure and Time Weighted Average for the LUVW

4.3 Raid Rehearsal Around Camp

It is common practice for infantry platoons to organize and perform a rehearsal prior to a patrol, raid or any other military actions. During this raid rehearsal, every aspect of the raid was carefully practiced by the platoon commander and the platoon warrant officer (platoon commander assistant) as follows:

- Tactical moves on the target objectives (to develop a cohesive group)
- Reaction to enemy encounters (to achieve immediate reaction)
- Plan to be executed to accomplish objective (to avoid any confusions)
- Practice of the different hand signals (to refresh basic military skill)
- Equipment checks

During this exercise, the reserve platoon being studied had to perform its rehearsal at the actual campsite. The camp was composed of a modular tent (sleeping facilities, eating facilities, etc.), electrical generators and a large number of travelling as well as parked vehicles.

In this complex set-up, the platoon was tactically moving between tents, generators, and vehicles simulating an approach to the target. It also simulated the attack on a mock enemy site. This rehearsal was representative of a typical infantry task, performed in a realistic setting. Because the platoon was on the campsite, it was unable to perform a weapons firing test. The rehearsal was performed at dusk, several hours before the actual raid departure (next morning).

It was decided to equip four members of a rehearsal platoon with noise dosimeters for the complete raid rehearsal. The total rehearsal time was approximately 1h 30 minutes (90 minutes). Nobody was wearing hearing protection during the rehearsal. When asked, the participants said that the task was representative of an operational raid rehearsal.

An average exposure with four soldiers in the rehearsal task was calculated with the three noise dosimeters setting (Settings 1, 2 and 3). These settings have different threshold levels. Noise exposure average per minute was calculated (see Table 19) and plotted on the graph below (see Figure 17). An average noise expose for 8 hours (TWA) was extrapolated for the data collected (see Table 20) using the three different settings (Settings 1, 2 and 3). There were no data below the threshold value from each dosimeter setting, i.e., 70 dBA for Settings 1 and 3, and 80 dBA for Setting 2.

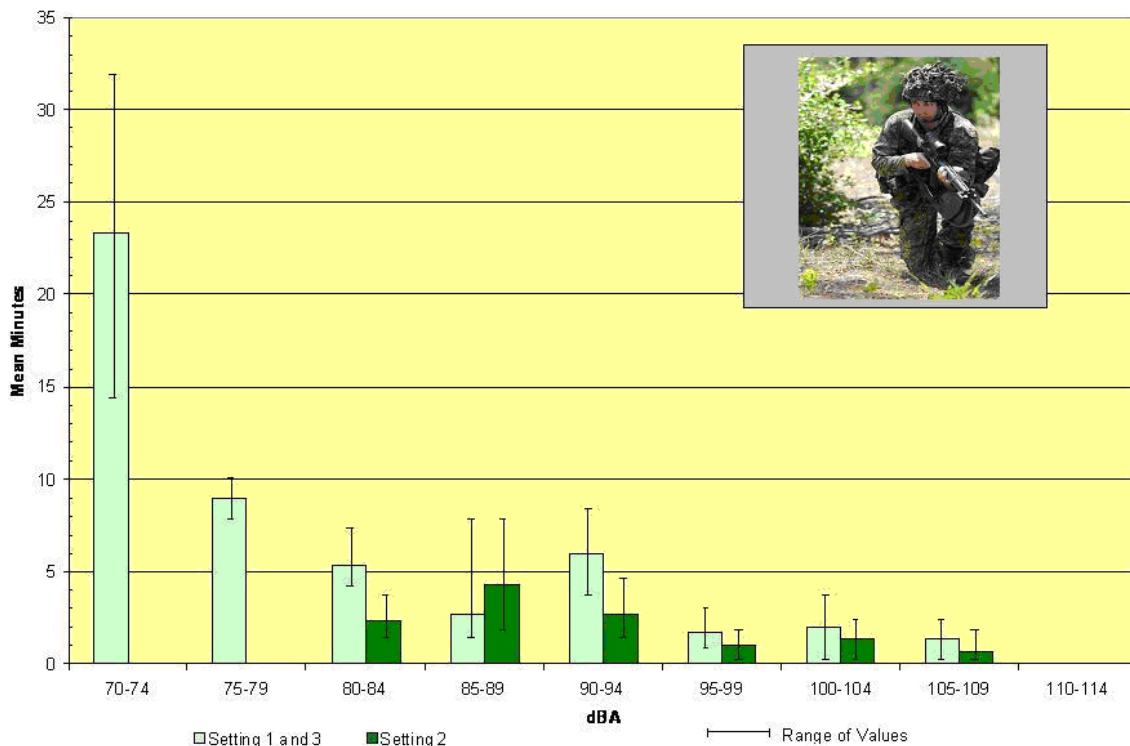


Figure 17 Rehearsal Noise Exposure Distribution

Picture From Combat Camera (www.combatcamera.forces.gc.ca)

	Settings 1 and 3 N=8	Setting 2 n=8
dBA	Minutes	Minutes
70-74	23.3	NA
75-79	9.0	NA
80-84	5.3	2.3
85-89	2.6	4.3
90-94	6.0	2.7
95-99	1.7	1.0
100-104	2.0	1.3
105-109	1.3	0.7
110-114	0.0	0.0

Table 19 Noise Exposure Distribution for the Rehearsal Task

	Dosimeter Setting N=8	
	Settings 1 and 3	Setting 2
Average Total Exercise (L_{AVG})	93.5dBA	83.6 dBA
Projected 8 hours time weighted average (TWA)	86.3 dBA	71.8 dBA

Table 20 Average Exposure and Time Weighted Average for the Rehearsal Task

5 Discussion and conclusions

Noise exposure in a military environment, especially in deployed operations is a challenging problem for hearing conservation specialists. Soldiers are primarily concerned with survival and mission execution. Despite the challenge of this setting, the principles of hearing conservation still apply:

- **Reduction of the noise emission at the source** – costly and difficult to implement
- **Distancing the individual from the source or placing behind a barrier** – not feasible in a military setting
- **Use of personal protection** – best possible option for military setting but obstacles exist.

Obstacles to the use of hearing protection by military personnel are numerous (8):

- **Incompatibility** of devices with others gears
- **Discomfort** if worn for extended periods
- Plugs fall out and are difficult to **refit** in the field
- Orders **cannot be understood**
- If the wearer has a hearing loss, the combination of hearing loss and the sound attenuation may be equivalent to **severe hearing loss**
- Difficulty of **operating weapons**
- Cannot **localize** the source of sound

In the various tasks surveyed during the exercise, most of these obstacles described previously were either witnessed by the experimental team or mentioned by the subjects themselves. Before discussing the noise exposure associated with the various tasks studied, a description of the current legislation on noise exposure is presented below.

5.1 Exposure Limit

Noise exposure limits in military settings are based on the Canada Labour Code exposure guideline (9), which recommends 87 dBA for 8 hours; for every 3 dB increment the duration must be halved. Table 21 below shows the exposure guideline:

dBA	Time
87	8 hours
90	4 hours
93	2 hours
96	1 hours
99	30 minutes
102	15 minutes
105	7 minutes 30 seconds
108	3 minutes 45 seconds
111	1 minute 52 second

Table 21 Canadian Labour Code Maximum Exposure Guideline

Across Canada, the provincial governments have their own noise exposure regulations that may differ greatly from the Canada Labour Code. For example, the Ontario Noise Legislation under the Ontario Health and Safety Act mentioned (OHSA) a time-weighted average (TWA) of 85 dBA with an exchange rate of 3 dBA. OHSA also suggests a ceiling exposure of 140 dBC. (Note: C-weighting incorporates a slight de-emphasis of the low and high portion of the audible frequency spectrum. It is the standard weighting used by the US Army for arms greater than 20mm.)

5.2 Raid Tasks

The overall noise exposure of the raid by the assault and support groups indicates that levels exceed limits specified by the Canada Labour Code guideline of 87 dBA for 8 hours:

- Exposure of 89.8 dBA for 8 hours for the Assault Group
- Exposure of 90.7 dBA for 8 hours for the Support Group

The noise exposure was concentrated during the Attach Peak and Helicopter Transport Peak periods which were 60 minutes and 15 minutes in duration, respectively. During this limited time frame, the noise exposure represents a true health hazard. Furthermore, the average noise level measured does not take into account the numerous impact noise exposures during assault.

This level of exposure could result in noise-induced hearing loss and thus hearing protection **should have been worn**. However, no hearing protection was worn or was even made available to the soldiers. When the soldiers were asked by the trial team why they did not wear hearing protection, they responded that:

- They did not view their exposure as unsafe, especially for the helicopter extraction
- They did not want to reduce their situational awareness for assault (i.e., understanding of orders and localization of sound sources)
- They did not have access to ear plugs
- Earplugs were uncomfortable if worn over a prolonged period

When the soldiers were asked by the trial team if they received any information regarding the danger of noise exposure, they said they had not.

5.3 Vehicle Exposure

All the soldiers involved in the vehicle task noise survey did not wear any hearing protection. No hearing protection was even made available to the soldiers prior the patrol tasks. All of the equipment checks were performed before exiting the camp but hearing protection was not an issue.

After the survey, when the soldiers were asked by the trial team why they did not wear hearing protection, they responded that:

- They did not think that their exposure was unsafe
- Nobody ever told them that their exposure could be unsafe
- They never saw anybody wearing ear plugs while driving in a military setting
- They were wearing a communication headset and they did not see the need for an ear plug (**incompatibility** of devices with others gear)
- They believed that wearing ear plugs would interfere with the mission (Orders would not **be understood**)
- They believed that wearing of ear plugs would interfere with situational awareness (Would not be able to **localize** the source of sound)
- They did not have access to ear plugs

5.3.1 G-Wagon Exposure

The overall noise exposure for soldiers in the G-wagon was 87.4 dBA (L_{AVG}) over 273 minutes (4 hours 33 minutes). The Canada Labour Code Guideline for a 4 hours 33 minutes exposure is approximately 89.4 dBA. Therefore this exposure is **lower than the guideline**.

5.3.2 Iltis Exposure

The overall noise exposure for soldiers in the Iltis was 83.6 dBA (L_{AVG}) over 274 minutes (4 hours 34 minutes). The Canada Labour Code Guideline for a 4 hours 34 minutes exposure is 89.4 dBA. Therefore this exposure is **lower than the guideline**.

5.3.3 Light Support Vehicle Wheeled (LSVW)

The overall noise exposure for soldiers in the LSVW was 104.4 dBA (L_{AVG}) over 340 minutes (5 hours 40 minutes). The Canada Labour Code Guideline for an 5 hours 40 minutes exposure is approximately 88.5 dBA. Therefore this exposure is **above the guideline**, and should be considered **hazardous to hearing**.

5.3.4 Heavy Logistic Vehicle Wheeled (HLVW)

The overall noise exposure for soldiers in the HLVW was 82.2 dBA (L_{AVG}) over 351 minutes (5 hours 51 minutes). The Canada Labour Code Guideline for an 5 hours 51 minutes exposure is approximately 88.4 dBA. Therefore this exposure **is lower then the guideline**.

5.3.5 Medium Logistics Vehicle Wheeled (MLVW)

The overall noise exposure for soldiers in the MLVW was 82.2 dBA (L_{AVG}) over 371 minutes (6 hours 11 minutes). The Canada Labour Code Guideline for 5 hours 51 minutes exposure is approximately 88.1 dBA. Therefore this exposure is **lower then the guideline**.

5.3.6 Light Utility Vehicle Wheeled (LUVW)

The overall noise exposure for soldiers in the LUVW task was 90.7 dBA (L_{AVG}) over 281 minutes (4 hours 41 minutes). The Canada Labour Code Guideline for 4 hours 41 minutes exposure is approximately 89.3 dBA. Therefore this exposure **is above the guideline**, and should be **considered hazardous to hearing**.

5.4 Rehearsal Around Camp

During rehearsal around the camp, soldiers were seen kneeling in close proximity to an idling truck and fuel generators, taking smoking breaks beside a truck, etc. The overall noise exposure associated with rehearsal was 93.5 dBA (L_{AVG}) over 90 minutes (1 hours 30 minutes). The Canada Labour Code Guideline for an exposure of 1 hours 30 minutes is approximately 94.2 dBA. Therefore this exposure **is lower than the guideline**.

All the soldiers involved in the rehearsal task did not wear any hearing protection. Hearing protection was made available to the soldiers prior the rehearsal task. All the equipment checks were performed before the rehearsal was done but hearing protection was not a concern.

After the survey, when the soldiers were asked by the trial team why they did not wear hearing protection, they responded that:

- They did not think that their noise exposure was unsafe
- They were wearing communication headsets and they did not see the need of ear plugs (**incompatibility** of devices with others gear)
- They believed that that the wearing of ear plugs would interfere with the mission. (Orders would not be **understood**)
- They believed that the wearing of ear plugs would interfere with situational awareness (Would not be able to **localize** the source of sound)
- They did not have access to ear plugs

In this case, soldiers were not exposed to hazardous levels of noise. However, rehearsal is sometimes performed a couple of hours prior to departure for a mission like the Raid Task. In this case, the platoon completed its rehearsal 7 hours before departure for the mission. The combined rehearsal, transport to the mission location, and actual task being performed may put the soldiers at **high risk for hearing loss**.

6 Recommendations

From this noise survey, it becomes evident that in some specific cases during this military exercise, noise exposures were above the Canada Labour Code guideline (Raid Task, Driving Task). Despite the fact that leadership was present and was participating in the activities, no hearing protection was used or even made available to the soldiers. Soldiers were not briefed about the level of noise exposure they would experience and the possible risk to their hearing. Clearly, information regarding noise exposure and NIHL are lacking.

Different strategies should be implemented as soon as possible:

- Safety and education seminars are needed at the different leadership levels on NIHL and prevention. These seminars should also include practical components on topics such as ear plug insertion.
- Noise prevention specialists should be engaged during major exercises or major deployments in order to give refresher courses and/or advice on noise safety and hearing protection.
- A team of noise prevention specialists should be required to visit reserve units across Canada and speak to troops about NIHL and alternative prevention strategies.
- New hearing protection devices integrated with communication capabilities should be introduced.
- A longitudinal study on NIHL for soldiers deployed on combat operations should be undertaken.
- A post-deployment health assessment questionnaire relating to NIHL should be implemented.

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ANNEX A

A.1 Voluntary Consent Form

VOLUNTARY CONSENT FORM

Title : Noise Dosimetry Survey of Land Force Occupations
Protocol #L-568

Principal Investigator: Capt. Eric Drolet, Experimental Diving and Undersea Group, DRDC
Toronto

Co-Investigator: Dr. Sharon Abel, Individual Readiness Section, DRDC Toronto

1. I, _____ hereby volunteer to participate as a test subject in an experiment to investigate noise exposure in Canadian Forces personnel. This experiment is titled "Noise Dosimetry Survey of Land Force Occupations" and the protocol number is "L-568". I understand the goal of this study is to upgrade the Canadian Forces hearing conservation program. As a participant I will be asked to wear a personal, pocket noise dosimeter during a mission period and complete a short questionnaire. A miniature microphone will be affixed to my collar. I have been told that such devices are routinely used to estimate noise exposure in workplace. They have no capability to record or reproduce conversation. The device will be fitted and removed by a trained technician.

2. I understand that, although my Base Commander has agreed to support this study, I am under no obligation to participate. My supervisors will not know whether I do or do not participate in this study. My participation is completely voluntary and entirely independent of my job and medical care. I have been informed that I may, at any time, revoke my consent and withdraw from the study without penalty or prejudice, and that the investigators may terminate my participation at any time, regardless of my wishes.

3. I understand that the information I provide will be held in strict confidence, and will be reported only as part of group trends. My results will be kept entirely confidential and anonymous and will be accessed only by the researchers involved in this study. Information which identifies me personally (e.g., my name, address, telephone number and service number) will be removed when the test results are presented or published.

4. I have been told that my participation in this study is completely non-invasive and poses no physical risk to me other than those associated with the performance of normal military tasks during training (e.g., bruise, superficial cuts). The results may benefit me in the future by helping to upgrade hearing conservation programs for the Canadian Forces that minimize the risk of hearing damage due to noise exposure.

5. I understand that I am free to refuse to participate and may withdraw my consent without prejudice or hard feelings at any time. Should I withdraw my consent, my participation as a

subject will cease immediately, unless the Principal Investigator determines that such action would be dangerous or impossible (in which case my participation will cease as soon as it is safe to do so). I also understand that the Principal Investigator or his designate responsible for the research project may terminate my participation at any time, regardless of my wishes.

6. I understand that I am considered to be on duty for disciplinary, administrative and Pension Act purposes during my participation in this experiment and I understand that in the unlikely event that my participation in this study results in a medical condition rendering me unfit for service, I may be released from the CF and my military benefits apply. This duty status has no effect on my right to withdraw from the experiment at any time I wish and I understand that no action will be taken against me for exercising this right.

7. I understand that for my participation in this research project, I am entitled to remuneration in the form of a stress allowance in a total amount of \$11.25 per day.

8. I understand that by signing this consent form, I have not waived any legal rights I may have as a result of any harm to me occasioned by my participation in this research project beyond all risks I have assumed.

Volunteer's Name: _____ **Signature:** _____
Date: _____

Name of Witness: _____ **Signature:** _____
Date: _____

Commanding Officer's Signature: _____
CO's Unit: _____ **Date:** _____

Principal Investigator: _____ **Signature:** _____
Date: _____

FOR SUBJECT'S ENQUIRY IF REQUIRED:

Should I have any questions or concerns regarding this project before, during, or after participation, I understand that I am encouraged to contact Defence R&D Canada – Toronto (DRDC Toronto), P.O. Box 2000, 1133 Sheppard Avenue West, Toronto, Ontario M3M 3B9. This contact can be made by surface mail at this address or in person, by phone or e-mail, to any of the DRDC Toronto numbers and addresses listed below:

Principal Investigator: Capt. Eric Drolet

Phone: (416) 635-2000

Email: eric.drolet@drdc-rddc.gc.ca

Chair, DRDC Human Research Ethics Committee (HREC): Dr Jack P. Landolt

Phone: (416) 635-2120

Email:

Jack.Landolt@drdc-rddc.gc.ca

I understand that I will be given a copy of this consent form so that I may contact any of the above-mentioned individuals at some time in the future should that be required.

A.2 Noise Survey

Dosimeter Serial No.

Microphone placement:

1. Date:	2. CF Base:
3. MOC:	4. Trade:
5. Service Number:	6. Rank:
7. Age:	8. Handedness (R or L):
8. Gender:	9. Length of Service in CF:
10. Please tell us your job and list your duties today, in order of occurrence; Jobs: _____ Duties: _____ _____	
11. Equipment used in this mission: _____ _____	
12. Vehicles used in this mission: _____ _____	
13.a. Weapon(s) used today: _____ _____	
13.b. What weapons did you have significant other EXPOSURE today? _____	
14. Do you think that the training exercise performed today was representative of a "real world" scenario? _____ _____	
15. Are you exposed to loud sounds in your civilian work? If yes, can you describe? _____ _____	

THANK YOU VERY MUCH FOR PARTICIPATING IN THIS SURVEY.
THE INFORMATION THAT YOU WILL PROVIDE WILL BE KEPT CONFIDENTIAL
RECORDS WILL NOT IDENTIFY YOU PERSONNALLY

List of symbols/abbreviations/acronyms/initialisms

CF	Canadian Forces
CFB	Canadian Forces Base
CHABA	Committee on Hearing, Bioacoustics, and Biomechanics for the National Academy of Sciences (USA)
CSA	Canadian Standards Association
dB	decibels
dBA	decibels, A-weighted
dB(C)	decibels, C-weighted
HLVW	Heavy Logistics Vehicle Wheeled
L_{EQ}	Equivalent continuous noise level - the average noise level over the period of measurement
L_{AVG}	Average sound level measured over the run time
LSVW	Light Support Vehicle Wheeled
LUVH	Light Utility Vehicle Wheeled
MLVW	Medium Logistics Vehicle Wheeled
NIHL	Noise induced hearing loss
OHSA	Ontario Health and Safety Act
OSHA	Occupational Safety and Health Administration (USA)
TWA	Time weighted average – averages the sampled sound over an 8-hour period
VAC	Veteran Affairs Canada
VG06	Vigilant Guardian 2006

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(U) This noise survey assessed the noise exposure sustained by combat arms personnel during a military exercise at Canadian Forces Base (CFB) Petawawa in 2006. Participants were asked to wear personal noise dosimeters during various basic operations (Raid, Convoy and Infantry Rehearsal Operations). Exposure beyond the allowed limit was documented in some operations (Raid and Convoy). Despite exposures beyond suggested limits, no hearing protection was wore or made available to the soldiers during the entire duration of the military operation.

(U) Le présent relevé de bruit a permis d'évaluer l'exposition reçue par des personnes œuvrant dans les armes combats lors d'un exercice de la réserve militaire à la base de Petawawa. On a demandé aux participants de porter des sonomètres intégrateurs personnels pendant différentes mission de niveau élémentaire. Des surexpositions au bruit on été noté dans certaines opérations, comme le dans l'assaut et l'extraction en hélicoptère. Aucun soldat ne s'est équipé de protection auditive ou n'a eu accès à des protections auditives tout au long de l'exercice.

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(U) Noise; Dosimetry; Exposure; Land Force; NIHL

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